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AN EXPERIMENT USING EMULSIFIED ASPHALT COLD MIX AS A SURFACING MATERIAL

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Introduction

Over the years, an obvious contributor to air pollution has been hot asphalt mixture plants. Contaminants are placed in the air from the burning of fuel needed for heating and drying aggregate; from dust produced by dry aggregate prior to mixing with asphalt; from the heating and mixing of the asphalt; from the completed mixture when it is dropped into a truck from a pug mill or storage bunker; and from the mixture when it is placed. Therefore, the California Division of Highways initiated a project to determine, by field trial and evaluation, if cold mixed asphalt concrete can satisfactorily comply with pollution standards and at the same time provide a durable asphalt concrete pavement.

The first project studied was a one-mile test section of a one-inch cold mixed asphalt concrete overlay. The section is located on Highway 30, near the City of Fontana in District 08 (Figure 1). The project was constructed in September 1971, with the cooperation of the Fontana Paving Co. and Chevron Asphalt Co.

Project Description

The test section consisted of a one-inch overlay placed over an existing asphalt concrete pavement by the Fontana Paving Co.

The section is located in San Bernardino County in District 08 headquartered in San Bernardino. (The exact location was between Post Miles 11 and 12 on Highway 30, referred to locally as Highland Avenue.) It was placed under contract 08-151824 (502).

Highway 30 is a 2-lane facility running east and west and carries approximately 4000 vehicles per day, 17% of which are trucks. The section selected for the experimental mixtures intersected only one street (East Ave.) which carries minimal traffic. Traffic on the highway is estimated to average 50 to 65 miles per hour.

The experimental section is located in an area with an average rainfall of about 15" per year. Ambient temperatures range from 115°F in the summer to a low of 25°F during the winter. Most of the project was shaded by tall Eucalyptus trees located within 20' of the south edge of the roadway. Drainage ditches are located along both sides of the roadway and the adjacent farmland consists of abandoned citrus orchards or uncultivated fields.

Materials

The aggregate was supplied from the Fontana Paving Company and in general was an all crushed stream bed gravel of good sound quality. The gradings selected to be used were: 1) a dense grading conforming to the tolerances for California's 1/2"

medium grading and 2) an open grading conforming to the tolerances for 3/8 x #6 seal coat screenings (Table 1).

The sand selected to be used as a choker for the open graded mixture was the material from their No. 1 bin at the plant (-8 fraction).

The emulsions were supplied by the Chevron Oil Company and were designated as a CMS-2h and a CSS-1h. The CMS-2h is a cationic medium setting type of emulsion which has a base asphalt with a penetration between 40 and 50. In addition, the emulsion contains an oil distillate to facilitate mixing. The CSS-1h is a cationic slow setting type emulsion having a base asphalt with a penetration between 60 and 70.

The tack coat was a CSS-1h emulsion diluted 3:1 and applied at the rate of .05 gallon per square yard.

Plant Operations

A conventional 3,000 lb. Madson Asphalt Plant was used to prepare the mixtures (Figure 2). The aggregates were not dried although they were fed to the plant through the dryer. (There was no firing of the dryer.) The aggregates were then allowed to be screened with the normal screens on the plant utilized for hot mixes. (Due to the dryness of the stockpiled material, which

essentially was all crushed, very little clogging of the screens was noted.) The screens were left in place merely for operational convenience of this particular project and were not a requirement.

The emulsion was pumped from the tank of a truck and trailer unit used for transport (Figure 3). With the use of a flexible hose, connections were made to route the emulsion to the plant, via the plant pump, and return to the trailer tank, thus setting up a system of continuous circulation. With the use of a three-way valve the emulsion was periodically drawn off and metered into the batch as required. A supply of water for premixing with the dense graded material was also made available and it was also metered as needed per batch. The plant's regular asphalt meter was used for the water.

Chevron Asphalt Company designed the mixes in the laboratory. However, in order to determine the proper percentage of emulsion and water that would actually be required, trial batches were mixed at the jobsite. These batches were placed on a plant access road (Lime Ave.). From these trials it was learned that approximately a 12 second mixing time would be required for the open graded mixture (3/8 x #6) and a 15 second mixing time would be required for the dense graded mixture. It became evident that the mixing time was extremely critical. Excessive mixing with either grading caused almost complete stripping of the

emulsion from the aggregate. Insufficient mixing also resulted in poor coating. The permissible range appeared to be about 3 seconds for the open and 5 seconds for the dense mixture. During actual production the mixing time was carefully adhered to, and as a result only two batches were discarded due to poor mixing.

The procedure for mixing the open graded mix was to batch out the aggregate, meter in the emulsion (CMS-2h), mix together for 12 seconds and dump into the truck. Emulsion content varied as shown in Figure 1A. The size of each batch was 2,500 lbs.

The procedure followed for mixing the dense graded mix consisted of batching the aggregate, adding a metered amount of water, mixing for 5-10 seconds, adding a metered amount of emulsion and mixing for 15 seconds and dumping into the truck. The size of each batch was 2,500 lbs.

The aggregate used in the mix, although not completely dry (around 0.5% moisture) was quite consistent during the operations; however, several moisture contents and emulsion contents were tried during the day for experimental purposes. (A strip map (Figure 1A) indicates the placement of the various mixtures in the street.)

Street Operations

After a haul of approximately 7 miles, the mixtures were placed with ambient temperatures ranging from 70° to 90°F under clear skies. The paving width was 10' (0.08' thick) and three adjacent passes were made for complete coverage of the 30' traveled way.

Prior to paving, 1,000 feet of tack coat was placed in the lane to be paved. A CSS-1h emulsion diluted 3:1 was used. This application gave an amount of emulsion equal to an asphalt residue of .05 gal. per sq. yd.

Equipment on the job consisted of a Barber Greene Paver, two 12-ton tandem steel wheel rollers and a 10-ton pneumatic roller with 34# tire pressure.

The paving started at 8 a.m. at Post Mile 11, in the westbound lane, and proceeded easterly toward Post Mile 12. The paver was loaded by end dumping into the hopper (Figure 4). The open graded mixture was placed first and it started from and abutted a 1/2" dense graded conventional hot mix that had been placed the previous day.

The construction sequence was (1) placement of the mixture, (2) rolling immediately with a steel wheel roller (1 coverage), (3) immediate application of a sand choker, (4) immediate rolling

with a steel wheel roller (1 coverage) (Figure 5), (5) immediate rolling with a pneumatic roller (2 to 3 coverages) (Figure 6), and (6) open to traffic.

The mixture gave the appearance of a good, well coated, conventional, open graded mixture. The sand choker was applied to stop pickup from the rolling operations. The roller was equipped with water to wet the wheels, however, there was still some pickup evident until a detergent was added to the water. The pickup was then minimized, however, the sand choker was still used on all the open graded placed.

The sand choker was placed by backing a dump truck with the bed inclined about 30° over the mixture (Figure 7). The first sand choker applied was seen to nearly hide the mixture with an estimated cover of 1/8" and was felt to be excessive. Subsequent amounts (after the first 100' of the first paved lane) were reduced so as to give the appearance of a lightly scattered sand effect.

All of the open graded mixture was placed before placing of the dense graded mixture.

The dense graded mixture was placed using the following construction sequence: (1) placement of the mixture, (2) rolling immediately with a steel wheel roller (2 coverages). The dense

graded mixture did not have a sand choker applied. This mixture after placing appeared to take longer to cure and several wet spots could be detected (Figure 8). After 4 to 6 hours the entire surface of the dense graded mixture was covered by a film of free water.

Traffic during paving was routed adjacent to the operation by a pilot car. Traffic was allowed on the first open graded section 45 minutes after placing. No visible rutting or distortion was apparent. Traffic was allowed on the dense gravel mixture in about 1 hour. Slight damage was noted in spots on the dense graded surface (Figure 9) where traffic had to turn across the lanes to avoid construction.

Air Pollution Measurements

The type of hot plant used on this project and its related stockpiles posed a difficult problem in comparing the hot and cold mixes. The downwind dust load from the stockpiles and plant was very high. The aggregate was fed to the pug mill dry in both cases. No measurable difference in downwind airborne dust from the plant was found in comparing the hot mix and cold mix operations.

Differences between hot and cold mix paving operations were:

1. There were no visible emissions produced when dropping a cold mix batch into the truck.

2. There were no products of combustion from the plant stock as the dryer was not operating.

3. There were no visible emissions created in the transfer of cold mixes from the truck to the paver or from the paver to the street.

All of the above emissions are created by hot mix asphalt paving operations.

The application of a choker course to the open graded cold mix caused a local dust problem downwind from the roadway. At night the dust reduced visibility on the traveled way.

Pavement Condition After 24 Hours

Both types of mixtures could be displaced by turning the heel of the foot 24 hours after placing. All the paving joints were so well knitted together that they were hard to detect.

The first section of open graded mixture had noticeable surface raveling. Subsequent sections of this mixture showed less severe raveling. It was felt that the raveling in the first section was due, at least in part, to placing the sand choker too early, thus retarding the curing which resulted in a lack of surface cohesion and manifested itself by raveling under traffic. Raveling was generally confined to the wheel track areas.

The dense graded mixture showed a slight amount of raveling.

There was also some visual evidence that the mixture had not cured completely. For example, a 2-foot section near each edge of the pavement appeared brownish compared to the rest of the pavement, which indicated the asphalt still was emulsified (Figure 10). The wheel track areas appeared black and cured; however, this apparently was only the surface and not indicative of the full depth. The fact that this area was not sufficiently cured in depth was confirmed a few hours later when a fog seal was applied consisting of CSS-1h emulsion diluted 3:1 and applied to obtain a theoretical 0.10 gal. per sq. yd. residue. Traffic was allowed immediately over the sealed area and as the emulsion in the fog seal began to break, it stuck to both tires and surfacing. The result was serious tearing and raveling of the surface (Figure 11). Rocks ripped from the surface were being thrown by the tires of fast moving traffic creating a hazard. Sand was immediately brought out and placed on the surface to blot the emulsion. This was successful and additional raveling and tearing of the surface was arrested.

Both experimental surfaces were noticeably rough riding after 24 hours. Apparently traffic had continued to compact the mixtures and as a consequence the surface was not as true a plane as it was after construction rolling.

Pavement Condition After 90 Days

The dense graded mixture in an area where the fog seal was not applied had substantial surface raveling (Figure 12). The area of dense graded mix with the fog seal also appears to have extensive surface raveling (Figure 13); however, it is difficult to estimate whether it has increased in severity from the original raveling caused by the early seal coat. District personnel feel there has been some progression of the surface scuffing or raveling since it first occurred.

The open graded mixture had not deteriorated greatly from the initial observations. It is evident, however, that a few rocks are still being displaced and a few areas in the wheel track are definitely beginning to indicate a raveling pattern. Hairline cracks are now becoming easily distinguishable and are an indication of reflection cracking (Figure 14).

The entire experimental area has a richer appearance than adjacent hot mixtures. This was very likely due to the seal coat activity in the experimental area.

The riding qualities of both mixtures are good and although raveling distress is becoming evident, at this time both mixtures are entirely adequate for use without maintenance.

The adjacent hot mixes appear to be in excellent condition. There is no indication of any type of distress.

Skid Resistance

Skid resistance measurements were obtained approximately two months after construction and the results are as follows:

	Average SN_{40}
Dense Graded Mix	
(1) No fog seal	55
(2) One fog seal	49
(3) Two fog seals	33
Open Graded Mix	55

These readings were obtained with a towed trailer skid tester operating in conformance with ASTM Test Method E-274.

It can be seen that the dense graded mix, without a fog seal, and the open graded mix have the same skid resistance; however, the dense graded surface, without a seal was badly ravelled at the time of testing (Figure 12). This ravelling would not be acceptable and fog seals, which reduce the skid resistance, are necessary.

The open graded mix not only has good skid resistance, but also has excellent surface drainage characteristics. This is illustrated in Figure 15 which shows the comparison between the open graded surface and the abutting hot mix dense graded surface during a

rainstorm. Figure 16 shows the comparison between the cold mix dense graded and the open graded during the same rainstorm.

It appears, at this time, that the open graded mix has good potential as a skid resistance treatment. This material may be particularily applicable in areas where ambient temperatures are too low for proper placement of hot mix open graded asphalt.

Conclusions

Few conclusions can be drawn at this early date. The experiment was successful enough so that additional trials will be made. Observations and tests will be continued until some definite durability trends are evident.

Acknowledgments

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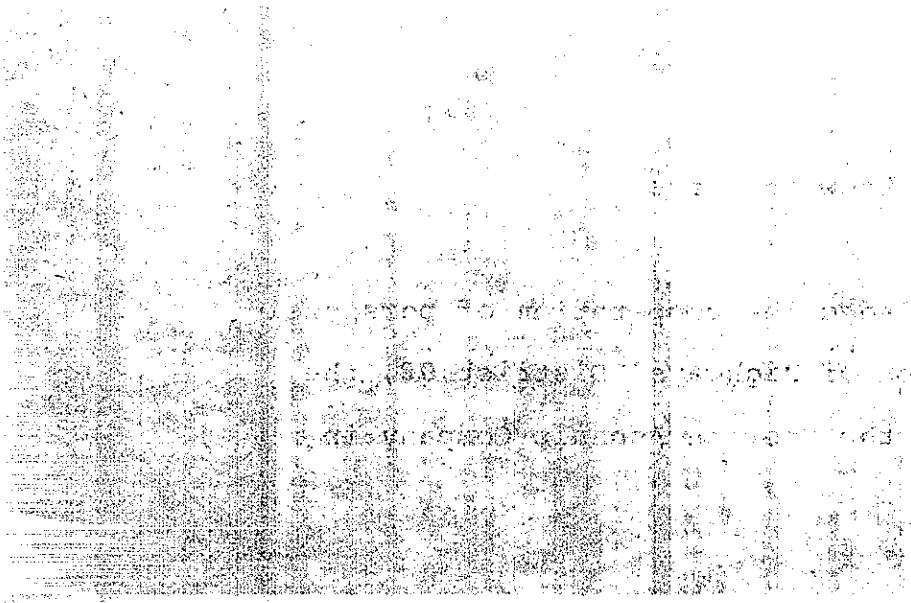
The opinions, findings and conclusions expressed in this report are those of the authors and are not necessarily those held by the Federal Highway Administration.



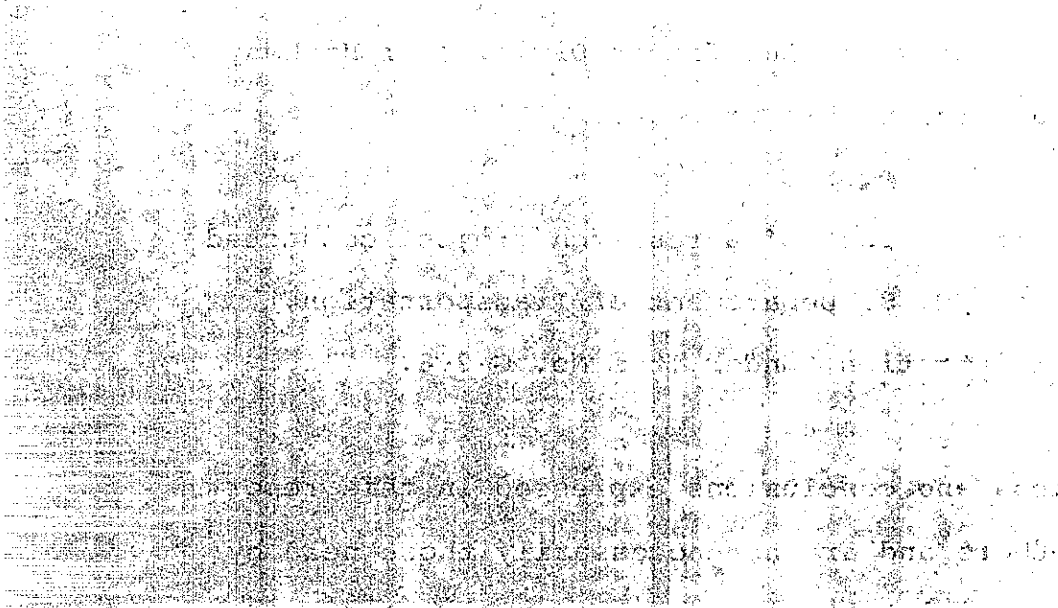


TABLE 1

Aggregate Quality Requirements

1/2" Max. Medium — Referenced in Text as Dense Graded

Sieve	% Passing As Used	% Passing Specifications (Section 39)
3/4		100
1/2	100	95-100
3/8	80	80-95
4	55	55-72
8	39	38-55
16	26	
30	19	18-33
50	12	
100	9	
200	6	4-8

Quality Tests

Test	Specification	Test Results
L.A. Rattler	50% Max. (After 500 Rev.)	22%
*K Factor	1.7 Max.	Kc=1.1 Kf=1.0
Sand Equiv.	45 Min.	66

(Choker Sand)

Sieve	% Passing
4	100
8	93
16	62
30	43
50	30
100	19
200	12

Specific Gravity Retained No. 4 = 2.65
Passing No. 4 = 2.70

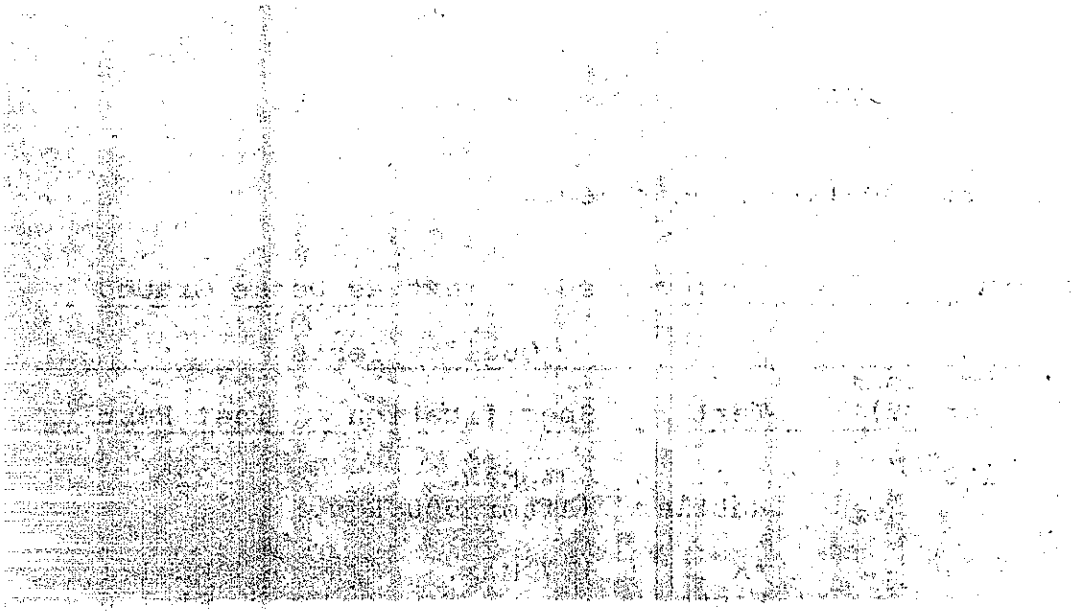
*From Centrifuge Kerosene Equivalent Test

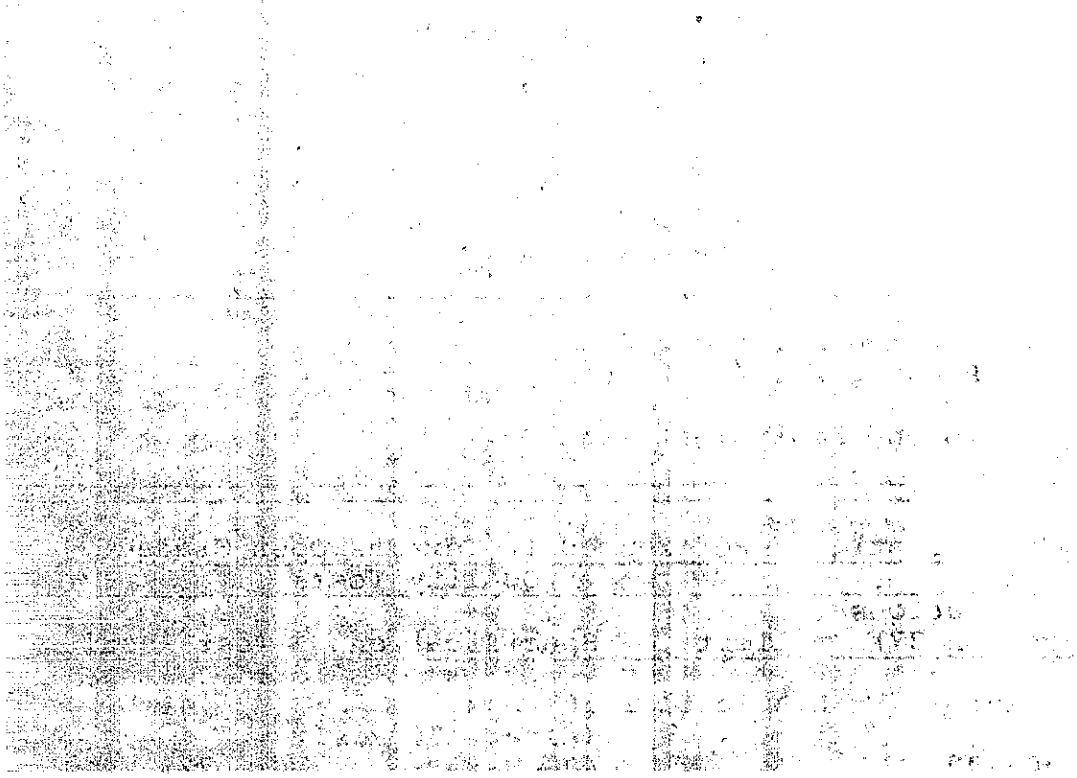
3/8 x #6 (Medium Seal Coat) — Referenced in Text as Open Graded

Sieve	% Passing As Used	% Passing Specifications (Section 37)
1/2	100	100
3/8	99	90-100
1/4	60	45-70
4	26	5-30
8	4	0-10
16	2	0-5
200	1	0-2

Quality Tests

Test	Specification	Test Results
L.A.Rattler	10% Max. (After 100 Rev.)	4%
	40% Max. (After 500 Rev.)	22%
Film Stripping	25% Max.	None
Cleanness	75% Min.	87%





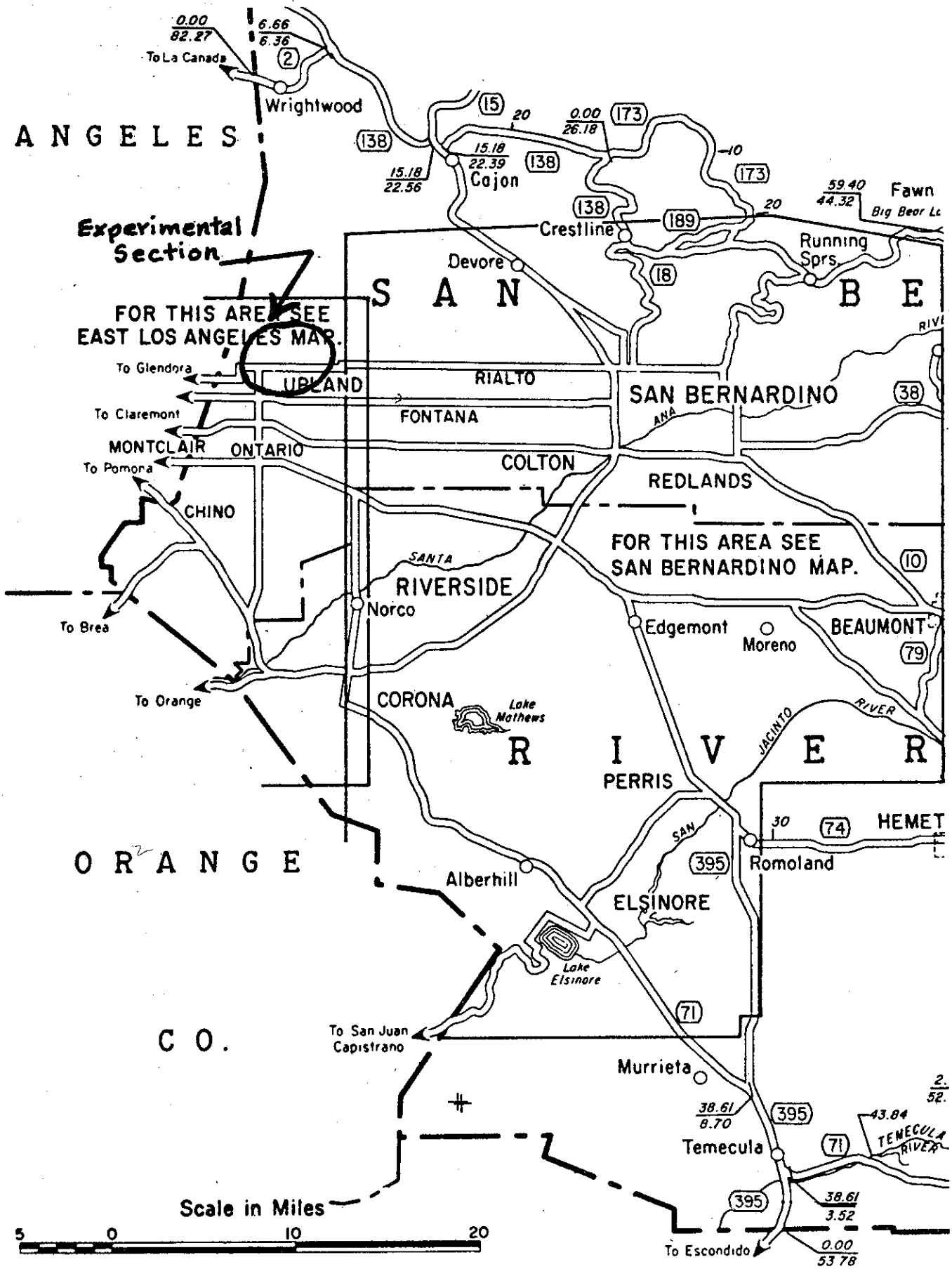
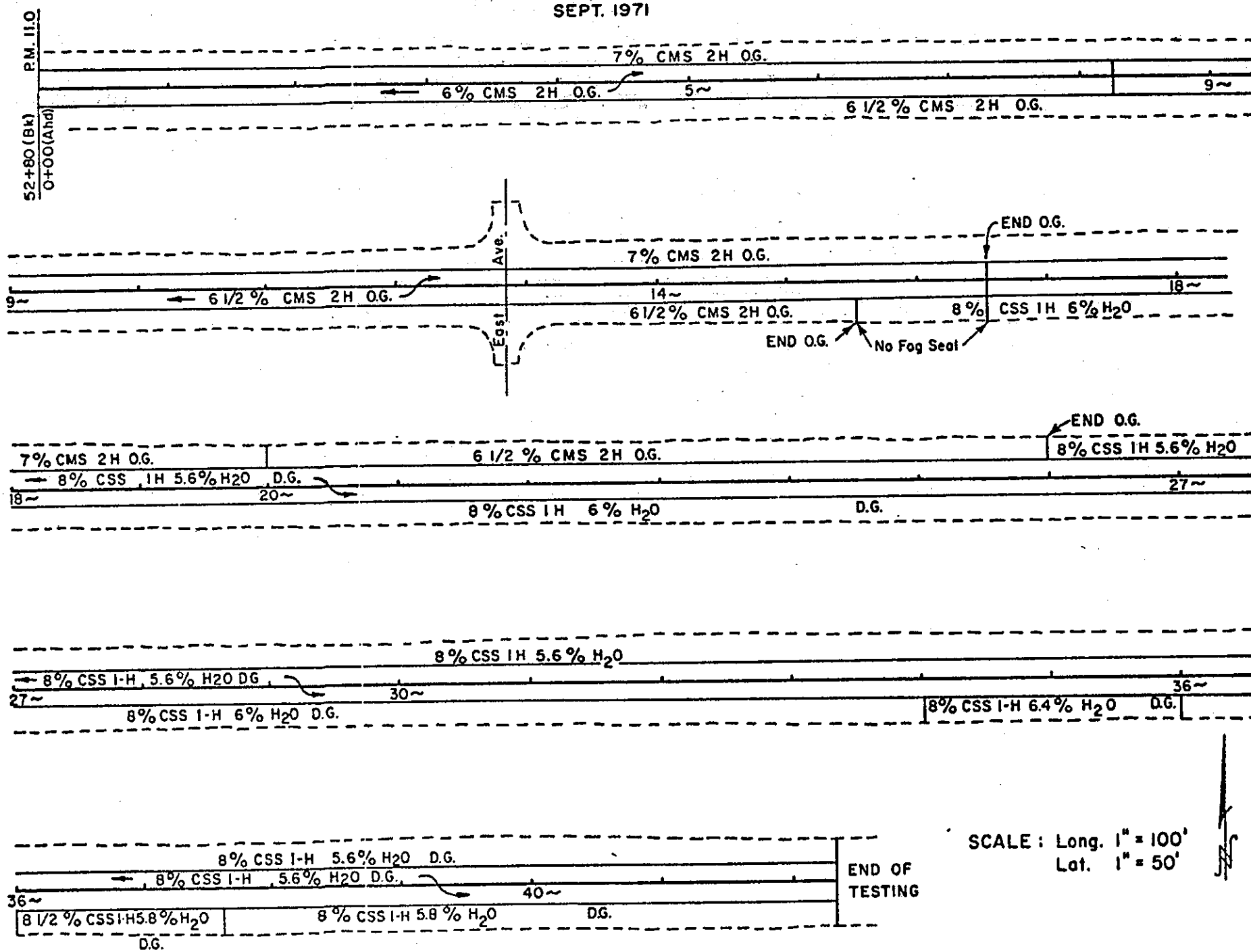


Figure 1

EXPERIMENTAL ASPHALTIC EMULSION BLANKET

08 - Sbd - 30, P.M. 10.5 to 13.0

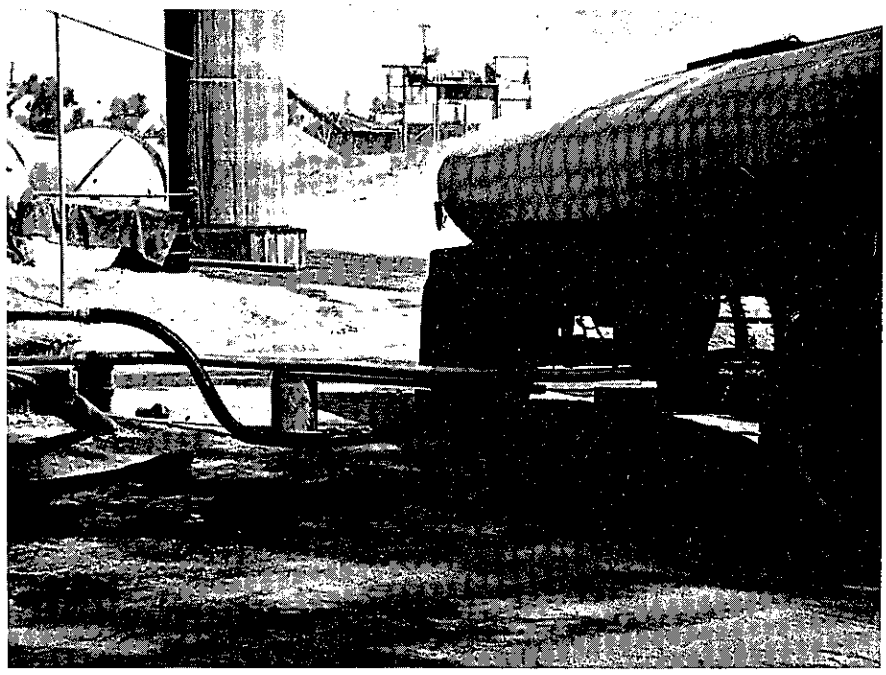
SEPT. 1971

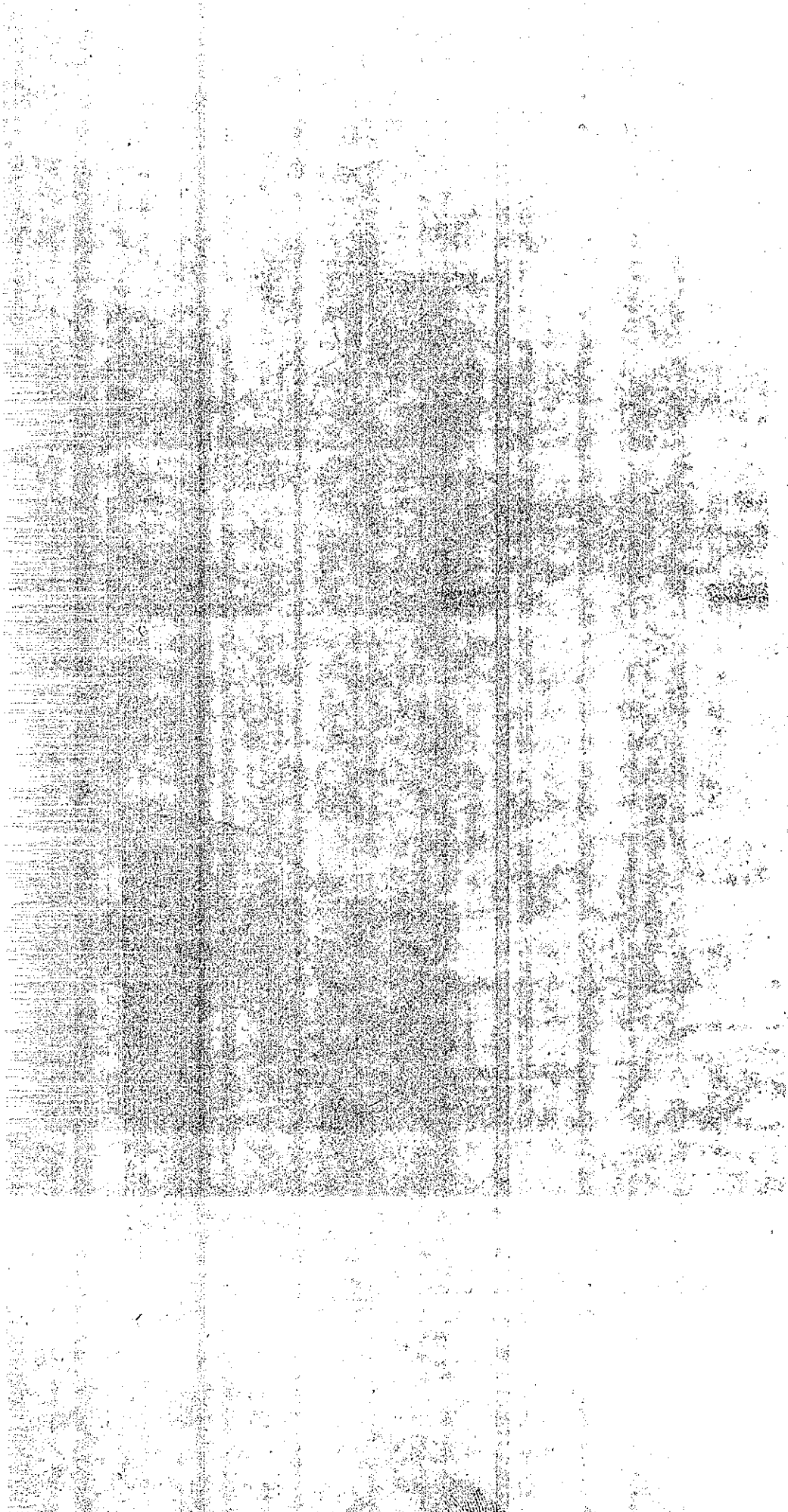


SCALE : Long. 1" = 100'
Lat. 1" = 50'

Figure 2
PLANT
OPERATIONS

Figure 3
EMULSION
FED TO PLANT
FROM TRUCK





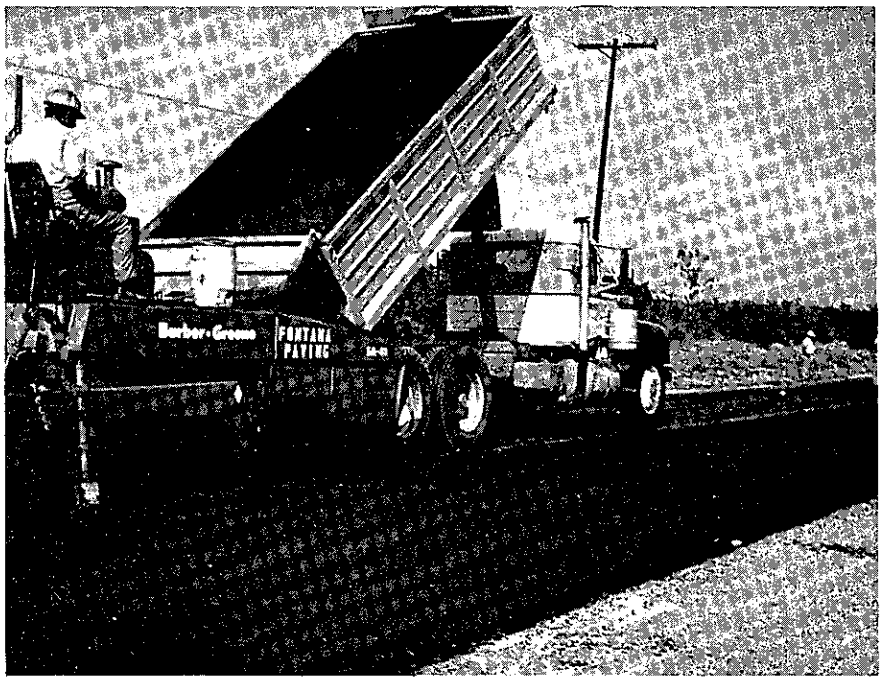


Figure 4
PAVING
OPERATION

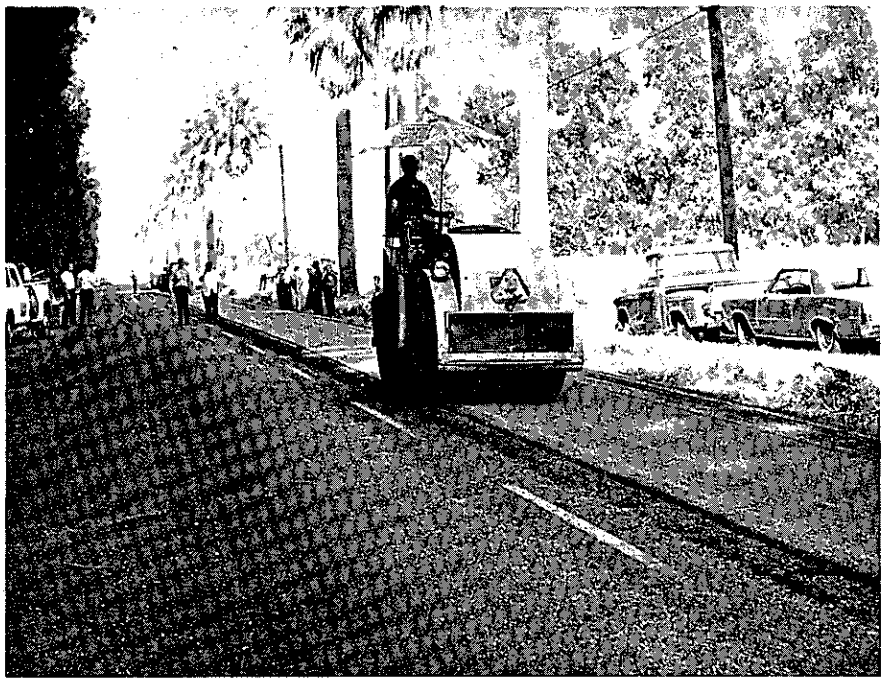


Figure 5
ROLLING
OPENGRADED
MIX

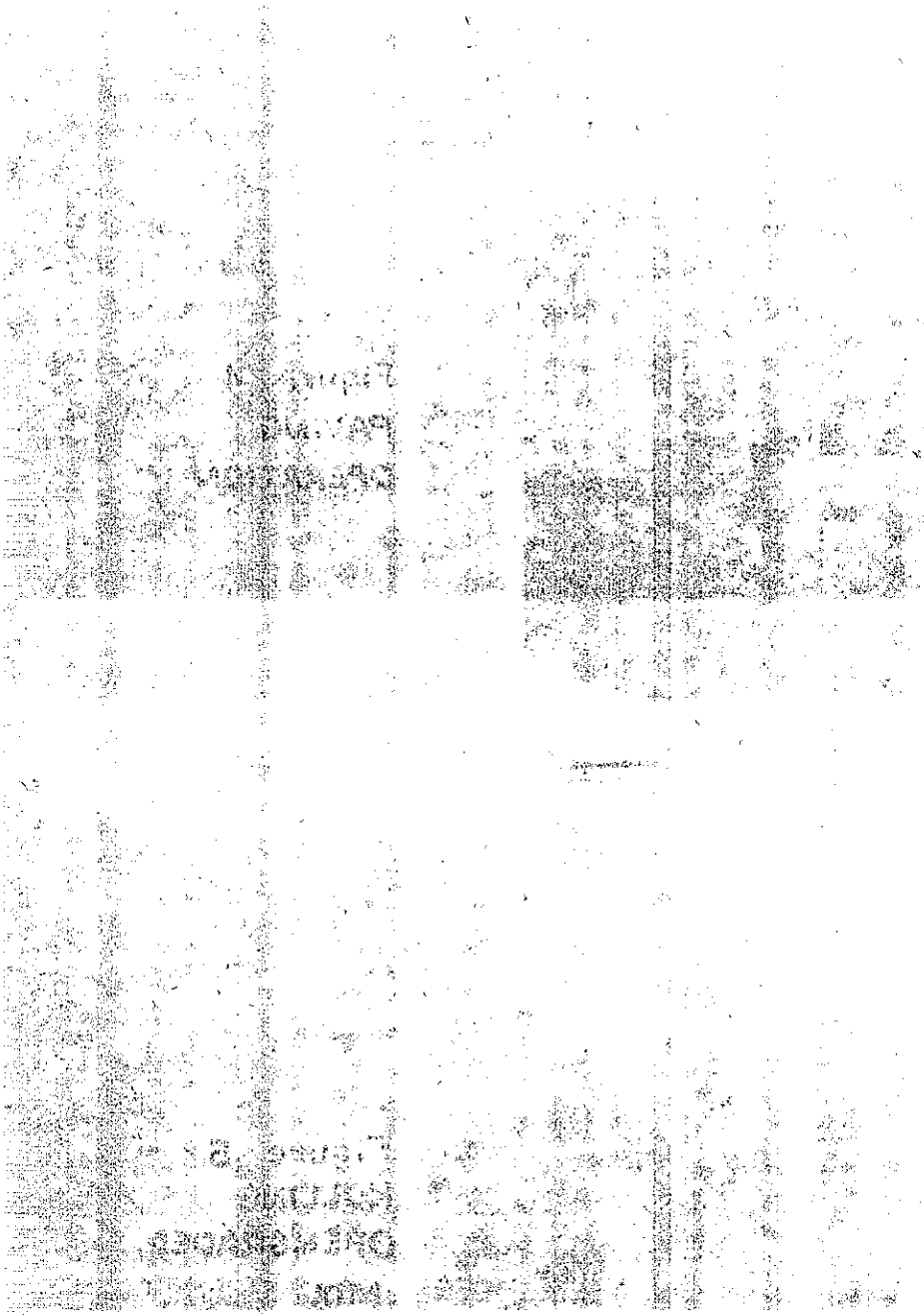


Figure 6
PAVING
OPERATIONS

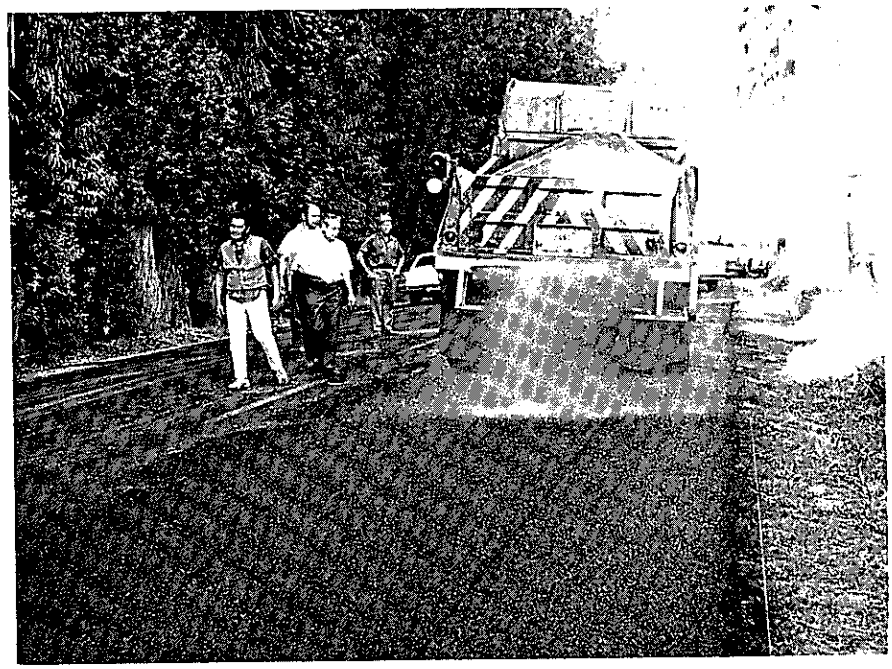
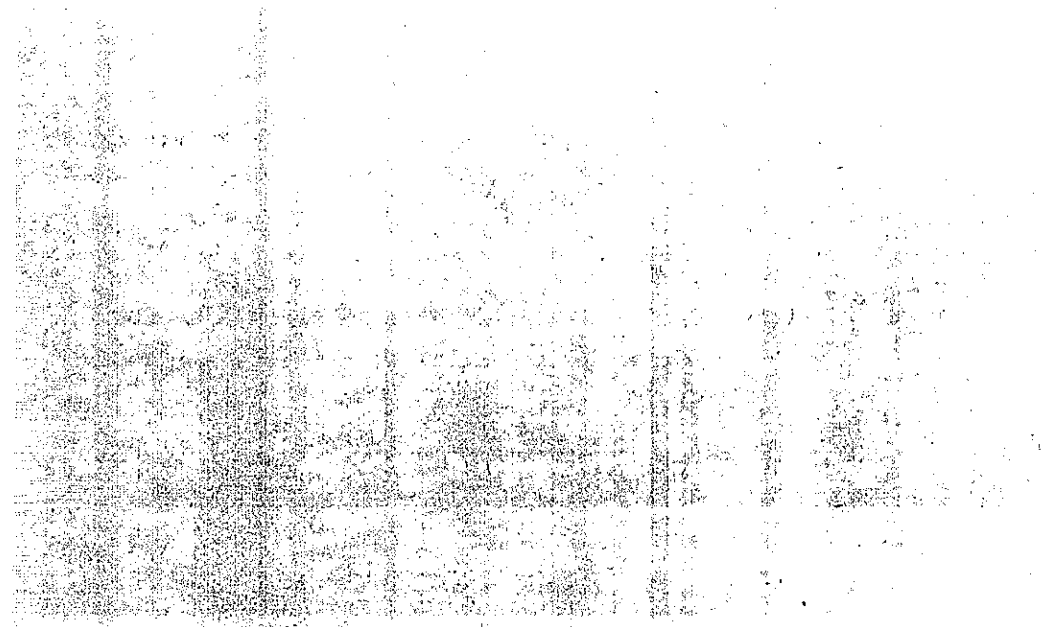


Figure 7
APPLYING
SAND CHOKER



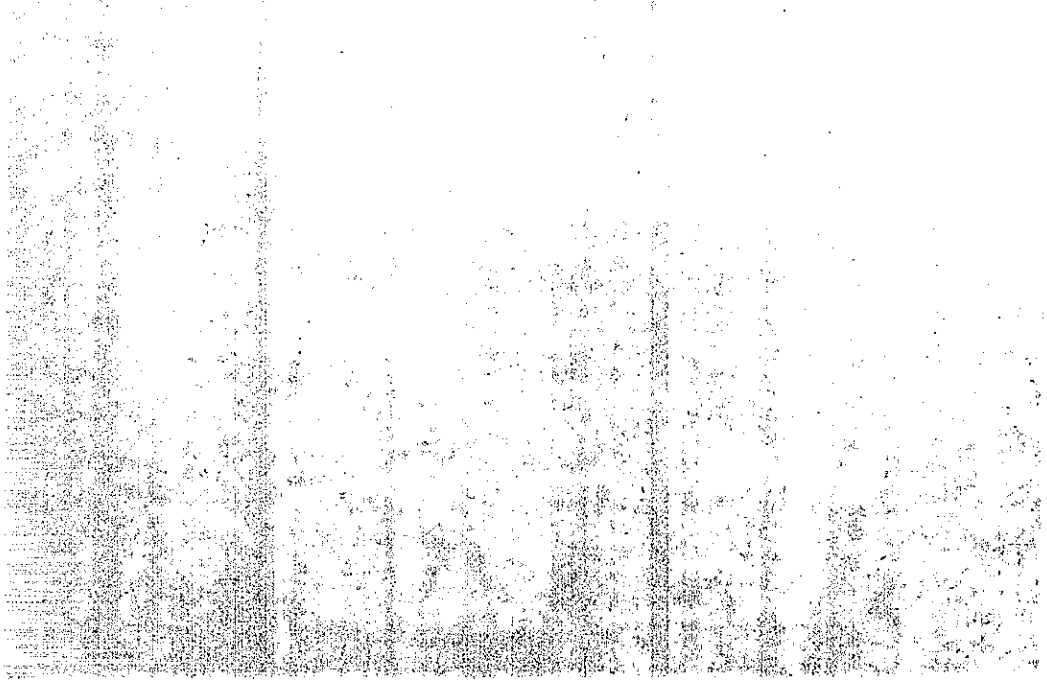
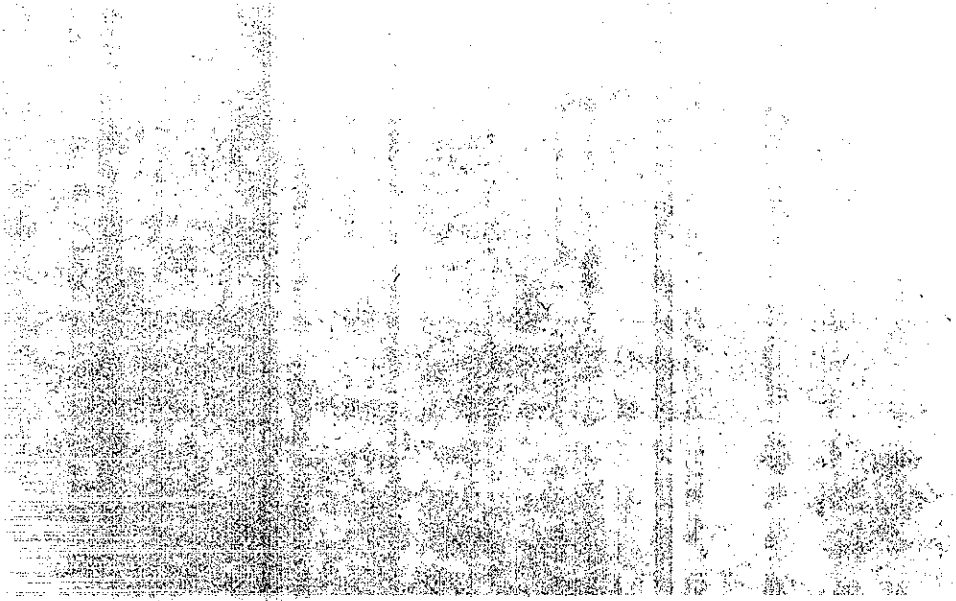
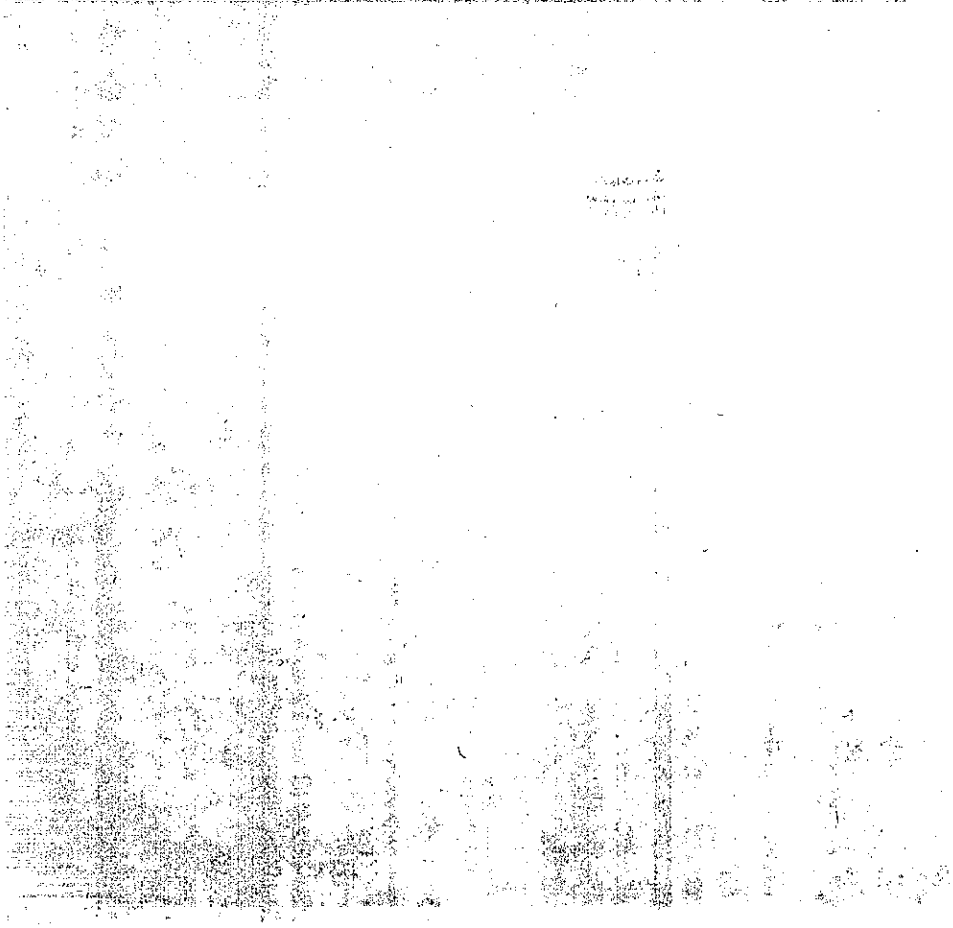


Figure 8
WET SPOTS FROM EMULSION APPEARING IN DENSE GRADED, SOON ENTIRE SURFACE APPEARED WET.

Figure 9
RAVELING IN DENSE GRADED DUE TO TURNING (4 HR.)





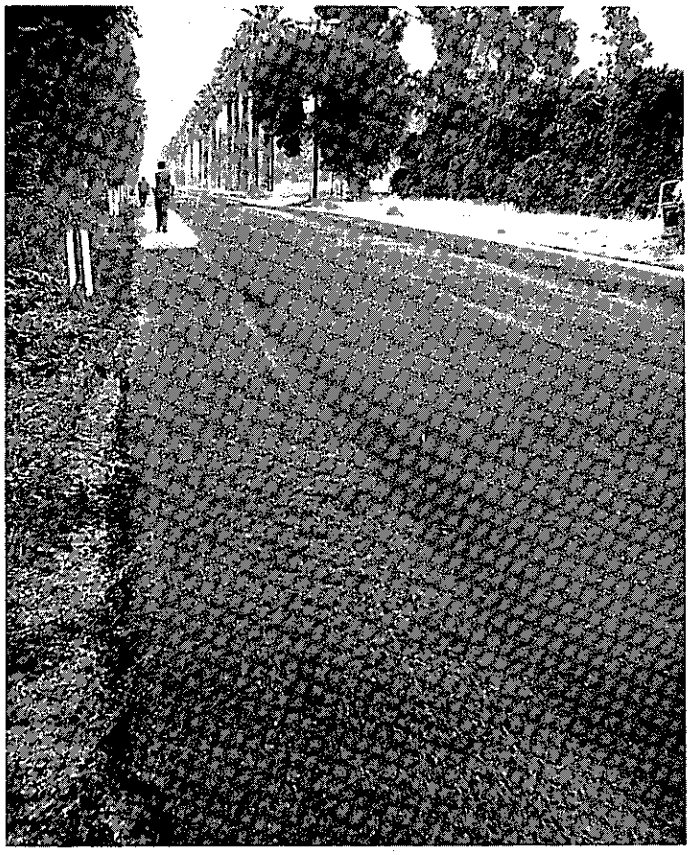


Figure 10
JUST PRIOR TO FOG SEAL, NOTE CONTRAST BETWEEN SHOULDER & TRAVEL WAY, INDICATING INSUFFICIENT CURE

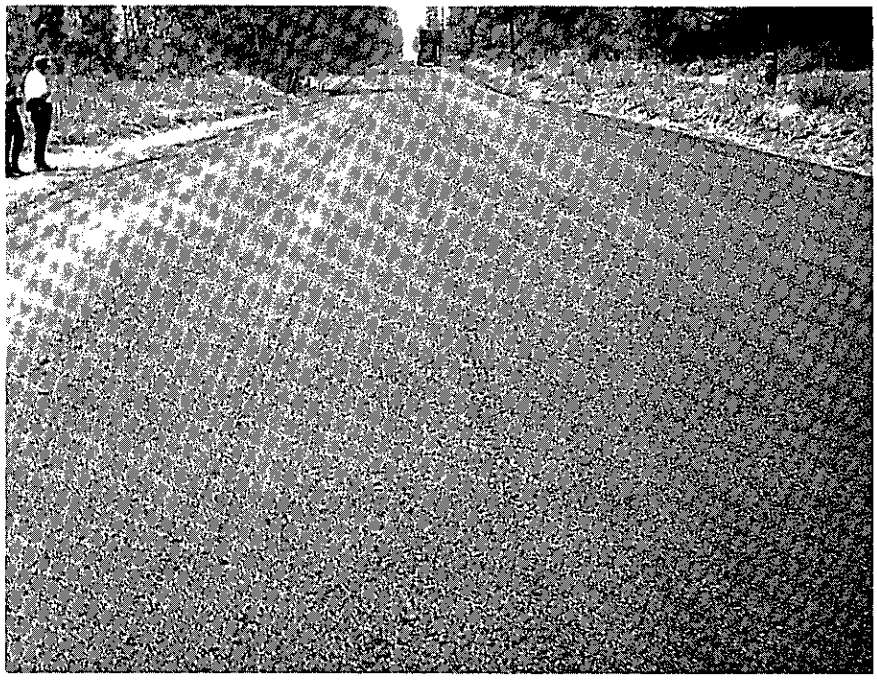
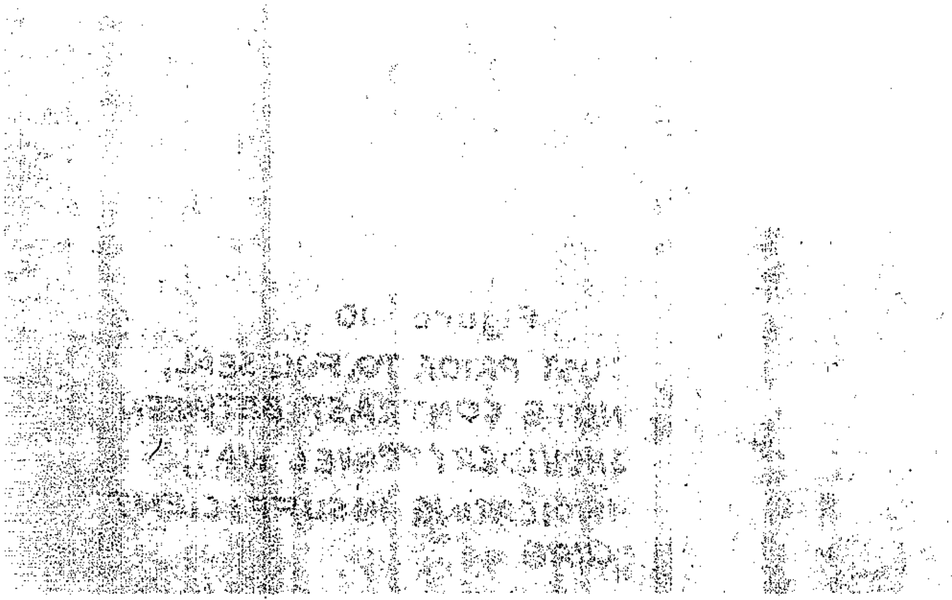


Figure 11
1 HR. AFTER FOG SEAL



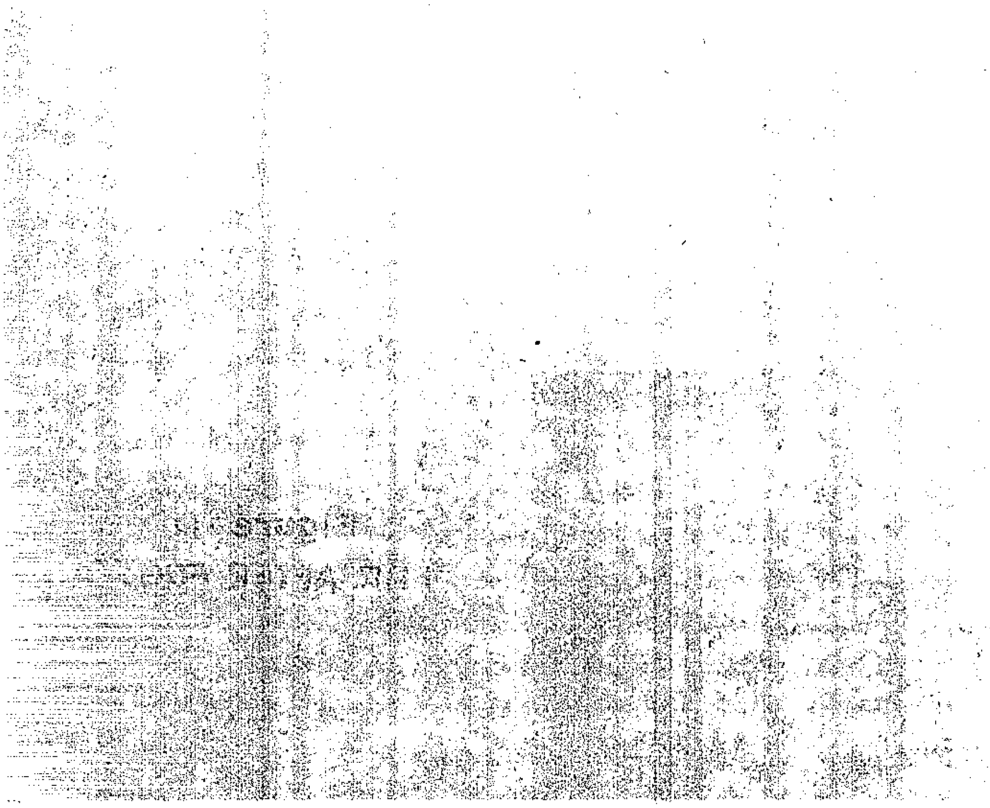
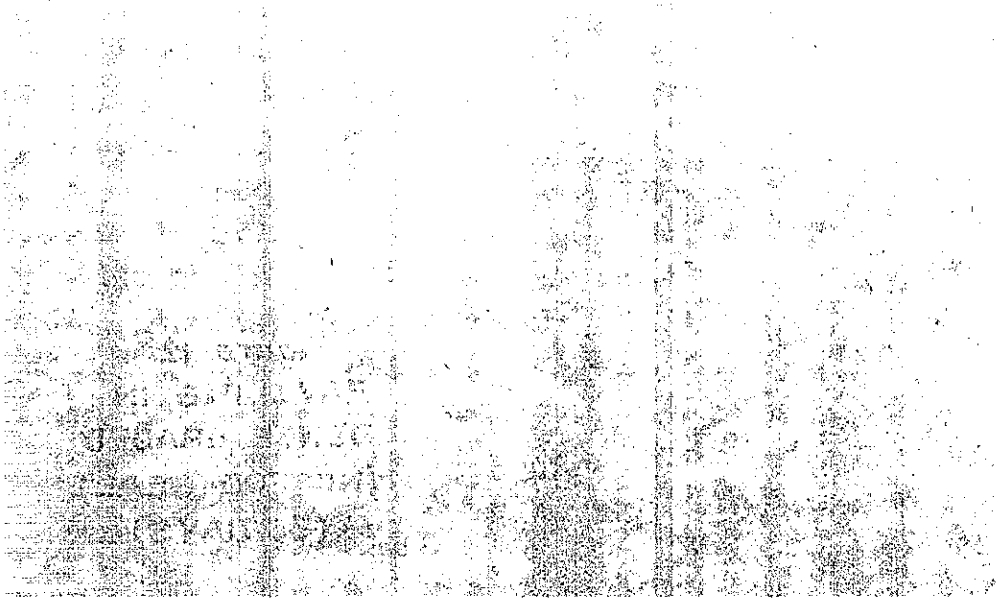
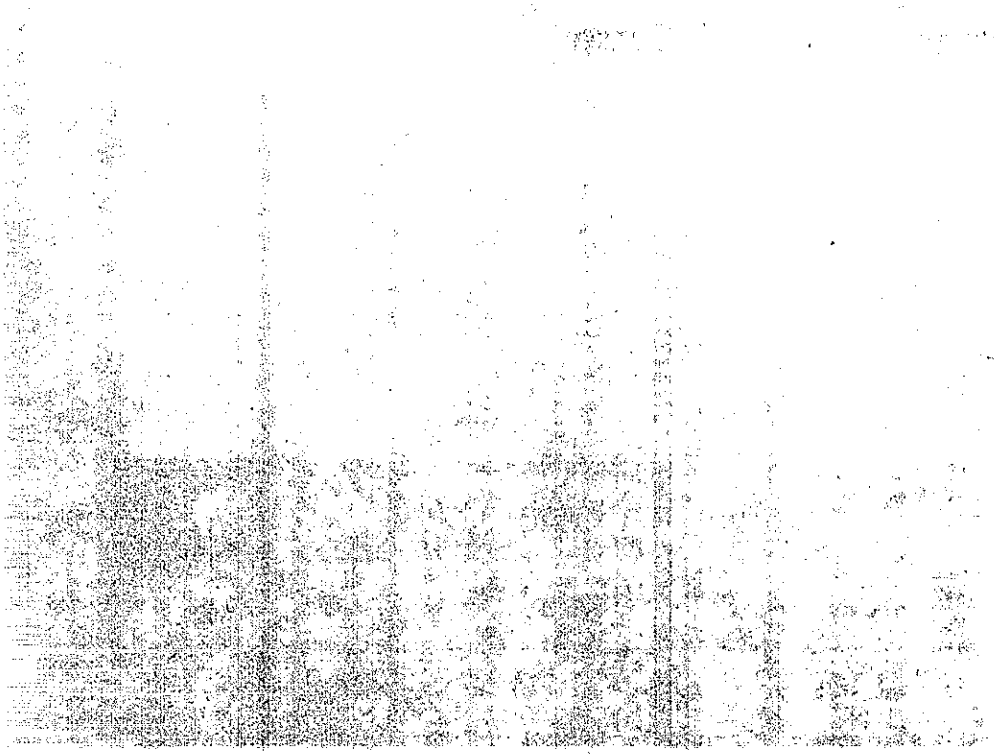


Figure 12
RAVELING IN
DENSE GRADED
(NO FOG SEAL)
(90 DAYS)

Figure 13
RAVELING IN
DENSE GRADED
(WITH FOG SEAL)





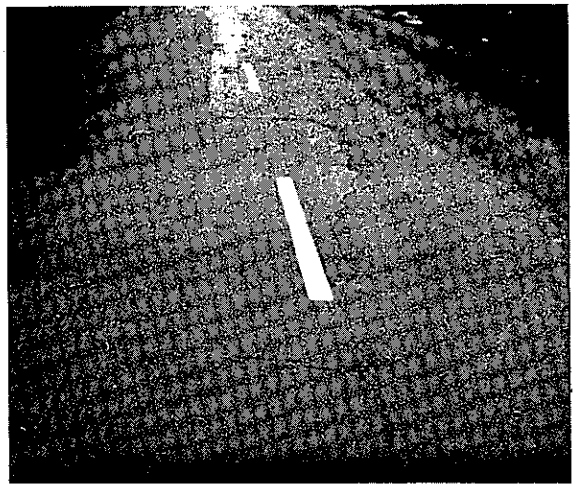


Figure 14
REFLECTION CRACKS
IN OPEN GRADED
(90 DAYS)

Figure 15
CONTRAST DURING RAIN,
OF HOT DENSE GRADED &
COLD OPEN GRADED

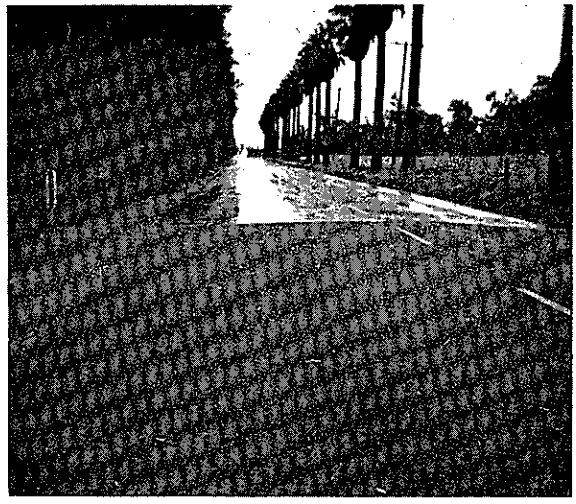


Figure 16
CONTRAST DURING RAIN, OF COLD DENSE GRADED & COLD OPEN GRADED

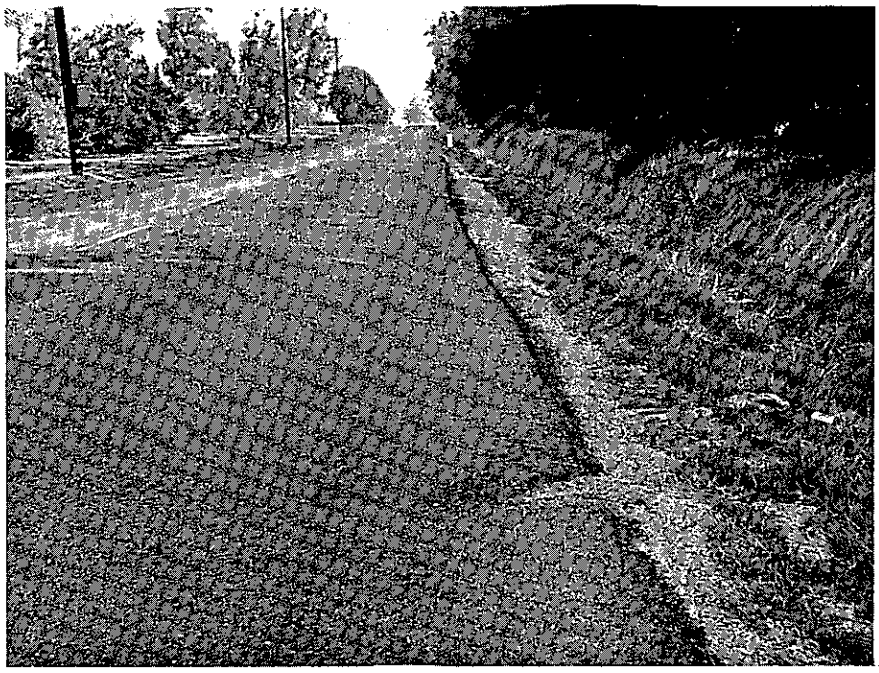
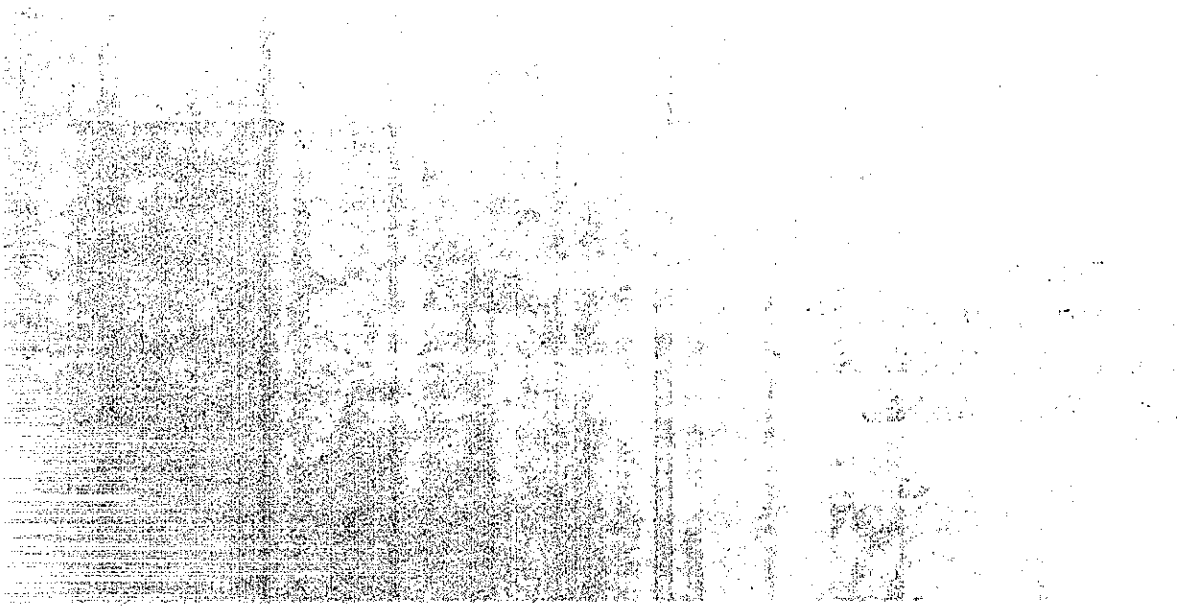
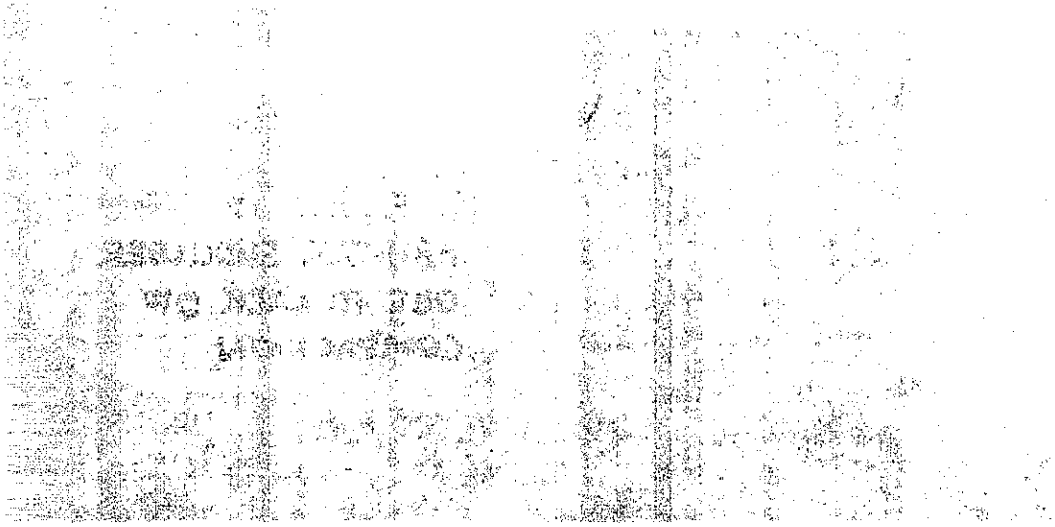


Figure 17
FRIABLE SHOULDER DUE TO LACK OF COMPACTION

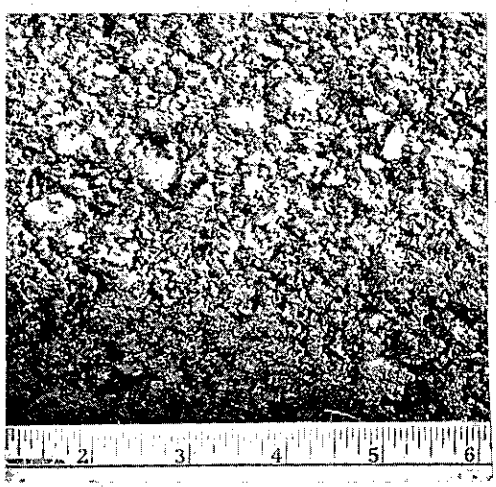




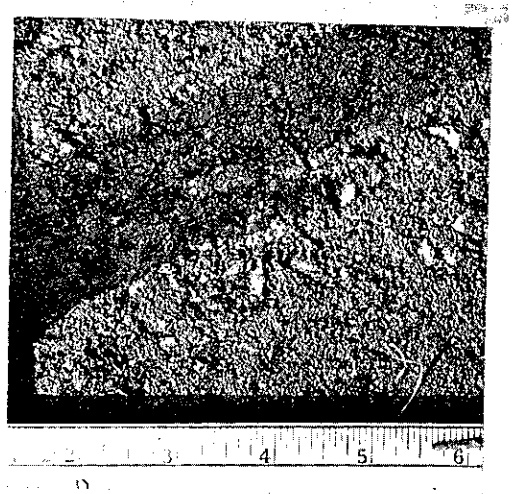
DENSE GRADED MIXTURE

TEXTURE PHOTOS

STATION 26 - SECTION E - POSITION 2

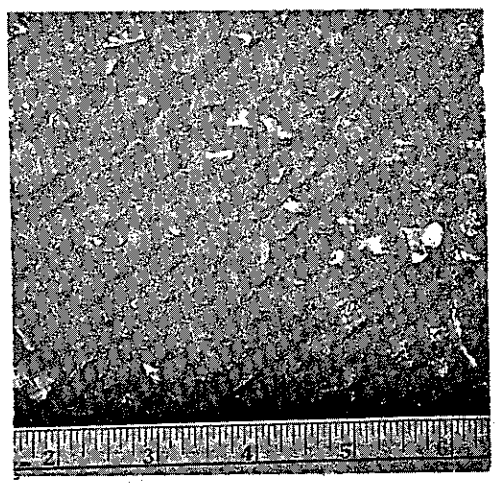


BEFORE BREAKDOWN ROLLING (1)

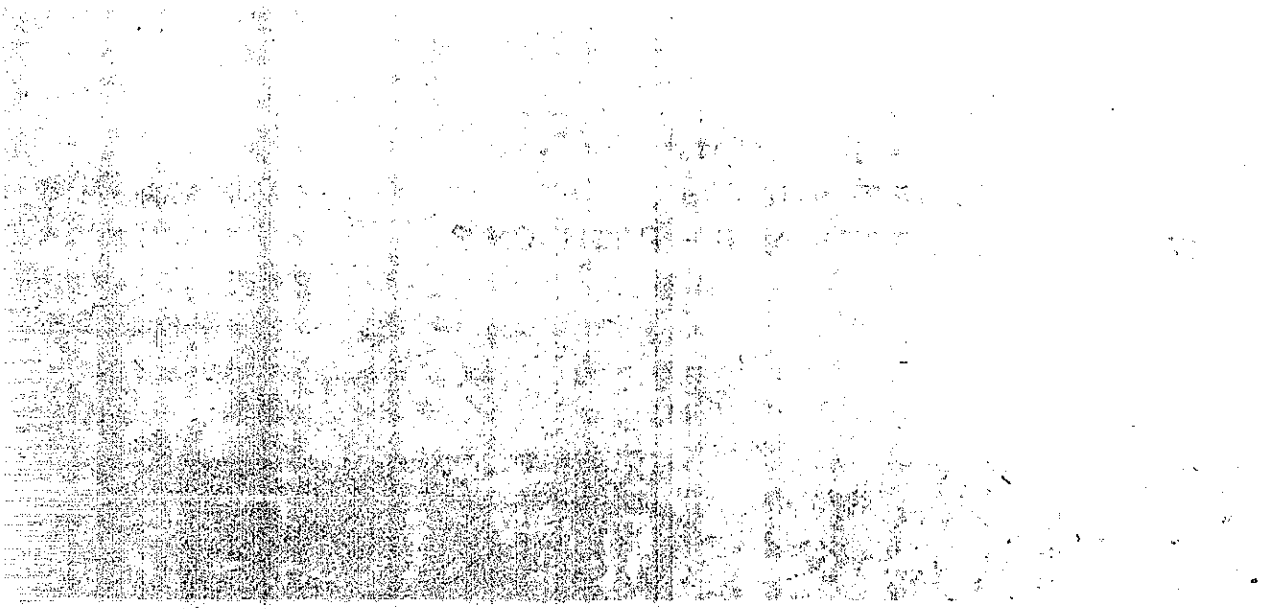


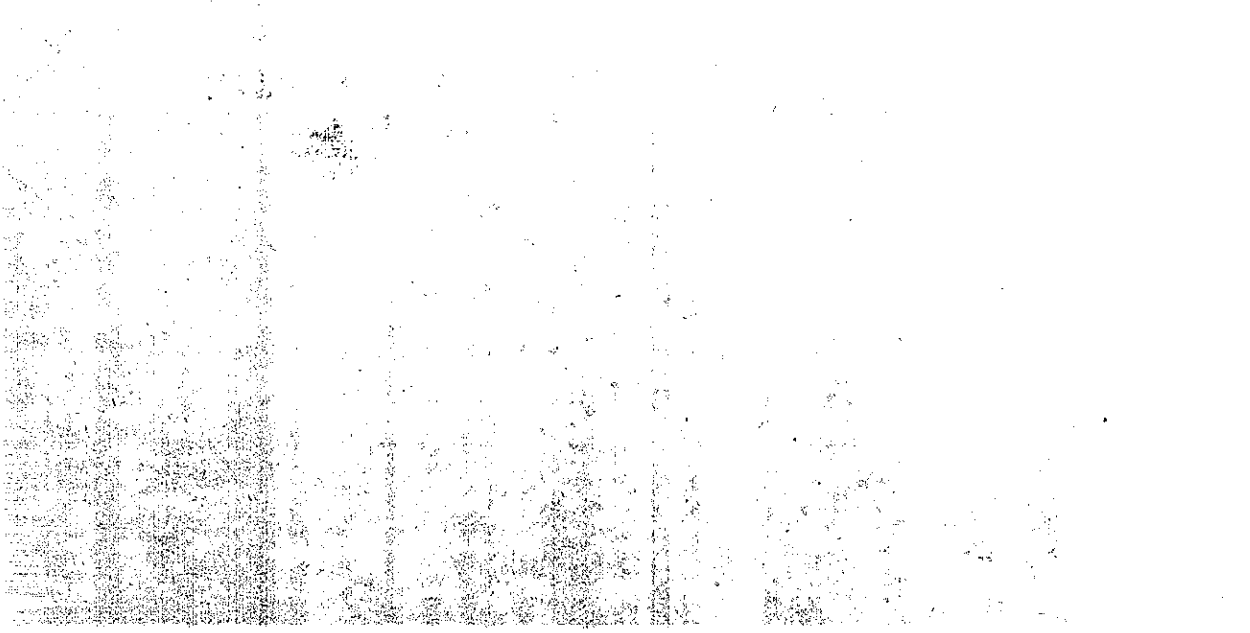
AFTER BREAKDOWN ROLLING (2)

AFTER 24 HRS. TRAFFIC (BEFORE FOG SEAL) (3)



AFTER 90 DAYS (4)



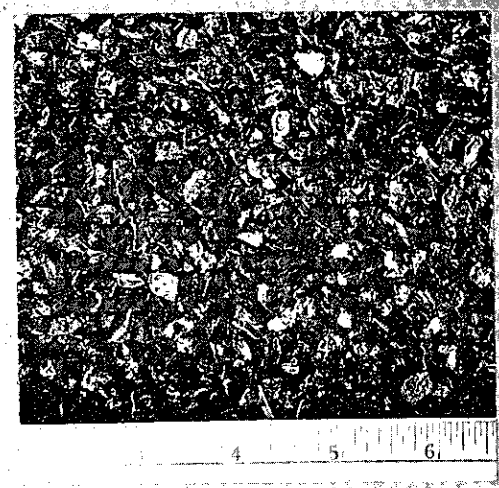


OPEN GRADE MIX (3/8 x #6)

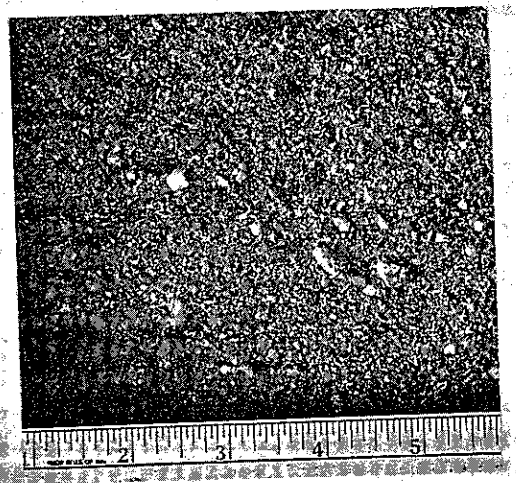
TEXTURE PHOTOS

STATION 0+20 - SECTION A- POSITION 2

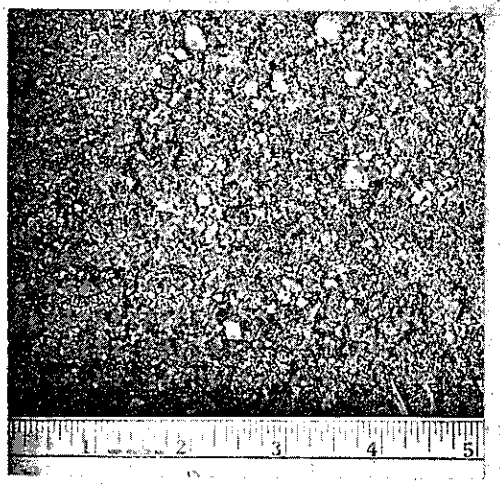
AFTER PLACING
(1)



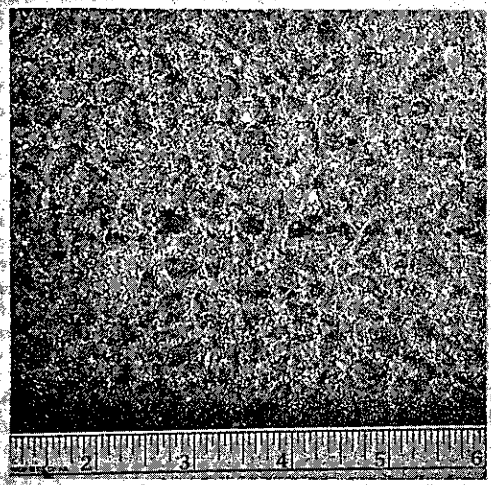
AFTER BREAKDOWN ROLL
(2)



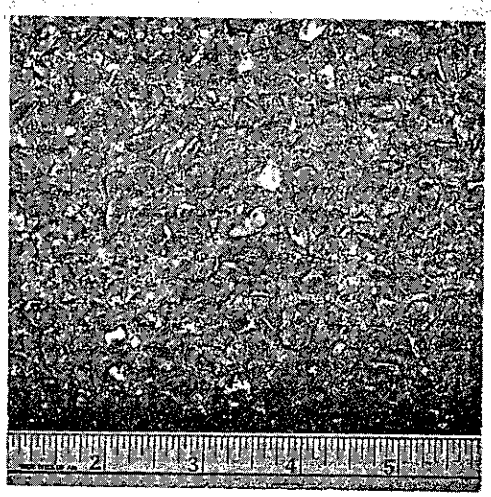
AFTER APPLYING SAND CHOKER
(3)



AFTER ROLLING SAND CHOKER
(4)



24 HRS. OF TRAFFIC
(5)



90 DAYS OF TRAFFIC
(6)